

Columbia River Project Water Use Plan

Kinbasket and Arrow Lakes Reservoirs Revegetation Management Plan Annual Report: 2007

- **CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis**
- **CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources**
- **CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir**
- **CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the Arrow Lakes Reservoir**
- **Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the Arrow Lakes Reservoir**
- **CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis**
- **CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area**
- **CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources**
- **CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation**
- **CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works (Phases 1 & 2)**
- **CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works (Phases 1, 2 & 3)**

Conditional Water Licences for Kinbasket storage (27068 and 39432), Mica diversion (39431), Revelstoke diversion and storage (47215), and Arrow storage (27066)

26 February 2008

BC Hydro Columbia River Project Water Use Plan Kinbasket & Arrow Reservoir Revegetation Management Plan Annual Report: 2007

1 Introduction

This document provides a summary of the status and results of monitoring programs and physical works being implemented under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan of the Columbia River Water Use Plan (WUP) to 31 January 2008, as per the Columbia River Order under the *Water Act*, dated 26 January 2007. There are eight monitoring programs and two physical works included within this Management Plan:

- CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis
- CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources
- CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir
- CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the Arrow Lakes Reservoir
- CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis
- CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area
- CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources
- CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation
- CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works (Phases 1 & 2)
- CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works (Phases 1,2 & 3)

2 Background

The water use planning process for BC Hydro's Columbia River project was initiated in August 2000 and completed in June 2004. The conditions proposed in the WUP for the operation of the project reflect the June 2004 consensus recommendations of the Columbia River WUP Consultative Committee (CC).

In July 2006, the Columbia River Draft WUP was submitted to the Comptroller of Water Rights (CWR). The draft WUP was sent out to regulatory agencies, First Nations and interested stakeholders for review. In January 2007, the CWR approved the final WUP and issued an Order to BC Hydro to implement the conditions proposed in the Columbia River WUP and prepare the monitoring programs and physical works Terms of Reference (TOR).

An addendum to the Columbia River WUP was submitted to the CWR in July 2007 after an Environmental Assessment Certificate was issued for the Revelstoke Unit 5

Project. The addendum proposes additional terms and conditions for the Columbia River WUP, as recommended by the Revelstoke Unit 5 Core Committee in December 2006, to address incremental impacts of the operation of the fifth generating unit at Revelstoke Dam.

In August 2007, the CWR accepted the Columbia River Project WUP Addendum resulting from the Revelstoke Unit 5 Project, and issued amendments to the Columbia River Implementation Order to include the commitments made by BC Hydro to undertake additional monitoring programs and physical works associated with the Revelstoke Unit 5 Project.

The following table outlines the dates that TOR for the Kinbasket and Arrow Lakes Reservoirs Revegetation Management Plan have been submitted to and approved by the CWR.

Monitoring Programs/ Physical Works TOR	Date Submitted	Date Approved
CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis	25 January 2008	
CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources	04 April 2007	19 April 2007
CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir	25 January 2008	26 February 2008
CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis	25 January 2008	
CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area	25 January 2008	26 February 2008
CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources	4 April 2007	19 April 2007
CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation	25 January 2008	
CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works (Phase 1)	27 April 2007	3 May 2007
CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works (Phase 2)	25 January 2008	26 February 2008
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works (Phase 1)	27 April 2007	3 May 2007
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works (Phase 2)	26 February 2008	
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works (Phase 3)		

As outlined in the Columbia River WUP, the Consultative Committee recommended a full review of the Columbia River Water Use Plan 13 years after implementation, unless results of the monitoring program suggest an earlier review is appropriate or significant risks are identified that could result in a recommendation to change operations.

BC Hydro will convene a multi-party panel five years after commencing the implementation of this WUP to evaluate the effectiveness of operations and physical works in meeting the stated objectives for Arrow Lakes Reservoir and the lower Columbia River. The outcomes from this process will be used to assess any potential need to review the Arrow Lakes Reservoir component of this WUP. If a replacement Non-Treaty Storage Agreement (NTSA) is negotiated within this 5-year period, it is also recommended that agreement provisions and implications be reported out through this panel. Signing of a new NTSA is not a trigger for panel evaluation or a review of this Water Use Plan recommendation to change operations.

3 Schedule

The following table (Table 3-1) outlines the current schedule for the monitoring programs and physical works being delivered under the Kinbasket and Arrow Lakes Reservoirs Revegetation Management Plan of the Columbia River Water Use Plan.

Table 3-1: Schedule of Columbia River WUP Monitoring Programs and Physical Works Implementation under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan

Monitoring Programs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
	WLR YR1	WLR YR2	WLR YR3	WLR YR4	WLR YR5 Interim Review	WLR YR6	WLR YR7	WLR YR8	WLR YR9	WLR YR10	WLR YR11	WLR YR12	WLR YR13 Final Review
CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis		■	■	■	■	■	■	■	■	■	■		
CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources	✓	■	■	■	■	■	■	■	■	■			
CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir		■	■	■	■	■	■	■	■	■	■	■	
CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation in the Arrow Lakes Reservoir			■	■	■	■	■	■	■	■	■	■	■
CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis		■	■	■	■	■	■	■	■	■	■		
CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area			■										
CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources	✓	■	■	■	■	■	■	■	■	■			
CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation				■	■	■	■	■					
Physical Works													
CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works - Phases 1 & 2	✓	■	■	■	■								
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works - Phase 1	✓												
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works - Phase 2		■	■	■									
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works - Phase 3					■	■							
Legend: <ul style="list-style-type: none"> ■ = Program to be undertaken/initiated in identified year u/w = Project is underway ✓ = Program completed for the year ✕ = Program started, but encountered operational or hydrological delays 													

4 Columbia River WUP Monitoring Programs - Kinbasket & Arrow Lakes Revegetation Management Plan

This section summarizes the status of the monitoring programs being implemented under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan of the Columbia River Water Use Plan, as per the Order under the *Water Act*, dated January 26, 2007.

4.1 CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis

4.1.1 Overview

In association with the Kinbasket Reservoir Revegetation Program physical works, the Columbia River Project WUP CC recommended effectiveness monitoring to ensure that the revegetation efforts are providing the intended environmental and social benefits over the long term. Given the considerable uncertainty regarding the potential effects of inundation on riparian and wetland environments, the WUP CC recognized that a monitoring program would be required to assess selected treatment techniques applied under the Kinbasket Reservoir Revegetation Program physical works, and to evaluate the effectiveness of revegetation efforts over the long term. The monitoring program was to focus on those components of the operating regime assumed to drive vegetation establishment (i.e., inundation depth, duration and timing) by imposing wet stress or dry stress over a defined period of time. This monitoring program will focus on monitoring existing vegetation and revegetated areas at the *site (local)* scale.

The objectives of this monitoring program are to:

- 1) Define and map the boundaries of the study area and define the biophysical and management strata that will structure the sampling methodology and analysis strategy for monitoring existing vegetation communities.
- 2) Document within-community responses (through monitoring of species cover, distribution, diversity, vigour, biomass and abundance) of existing vegetation communities to environmental conditions, including the current operating regime, through a plot-based assessment.
- 3) Assess the effectiveness of the revegetation program at expanding the quantity (as measured by cover, abundance and biomass) and quality (as measured by diversity, distribution and vigour) of vegetation in the drawdown zone under the current operating conditions (i.e. timing, frequency, depth and duration of inundation) over a 10-year period.
- 4) Assess the response of revegetated communities and their species assemblages to environmental conditions, including the current operating regime (i.e. inundation timing, frequency, depth and duration) through plot-based monitoring at the site level over a 10-year period.
- 5) Maintain a data collection and management database for the period of the monitoring program.

These objectives will be addressed by assessing the specified response variables at sample sites, stratified by primary topographic and biophysical criteria, under the various treatment options relative to control sites (areas of naturally established vegetation and barren sites). Vegetation responses will be monitored over a range of geographic areas within the drawdown zone of Kinbasket Reservoir, based on locations selected for treatment and control under the Kinbasket Reservoir Revegetation Program physical works.

This monitoring program involves:

- 1) Determining the species composition (i.e., distribution, distribution and vigour) of existing vegetation communities to identify species that have been successfully surviving long-term inundation;
- 2) Evaluating the cover, abundance and biomass of existing vegetation communities in relation to elevation in the drawdown zone;
- 3) Monitoring the response of existing vegetation communities at the local (site) level to the continued implementation of the operating regime for Kinbasket Reservoir and other environmental variables;
- 4) Assessing the long-term effectiveness of the revegetation program at expanding the quality (as measured by diversity, distribution and vigour) and quantity (as measured by cover, abundance and biomass) of vegetation in the drawdown zone for ecological and social benefits; and,
- 5) Assessing the costs and benefits of the revegetation prescriptions applied under the Kinbasket Reservoir Revegetation Program physical works by monitoring the response of revegetated communities to different treatments in the drawdown zone of the reservoir.

4.1.2 Status

This monitoring program has not yet been initiated. Terms of Reference were submitted to the CWR on 25 January 2008, and Leave to Commence is pending. Monitoring will commence in June 2008 and will be carried out over 10 years. The first program report is expected in December 2008.

4.1.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.2 CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources

4.2.1 Overview

During the Columbia River WUP process, the WUP CC made several assumptions regarding vegetation tolerances to inundation and responses to changes in the hydrologic pattern, based on information gained from studies in the Arrow Lakes Reservoir. Given differences in the elevation, climate and operating regime of the two reservoirs, the WUP CC recognized the inherent uncertainties of any assumptions related to the response of vegetation to reservoir operating conditions, and

acknowledged the importance of long-term data collection for assessing the effects of the operating regime on vegetation at different spatial scales.

The Kinbasket Reservoir Inventory of Vegetation Resources monitoring program will address key uncertainties related to the relative contribution and importance of the current reservoir operating regime (i.e., timing, duration and depth of inundation, and multi-year stresses) on the maintenance of existing vegetation communities delineated at the landscape scale.

The objectives of this monitoring program are to:

- 1) Identify and spatially delineate existing riparian and wetland vegetation communities within the drawdown zone;
- 2) Measure the spatial extent, structure and composition (i.e. distribution and diversity) of the communities in the drawdown zone at repeated time intervals over a 10-year period;
- 3) Assess whether there are changes in the spatial extent, structure and composition of the communities in the drawdown zone over the monitoring period;
- 4) Assess whether observed changes in the spatial extent, structure and composition are attributable to the current operating regime of the reservoir; and,
- 5) Provide information on the effectiveness of the current operating regime at maintaining the existing spatial extent, structure and composition of the communities in the drawdown zone.

These objectives will be addressed through a landscape level analysis of vegetation community changes over time in response to the current operating regime of Kinbasket Reservoir.

This monitoring program involves evaluating changes in the existing vegetation communities in the reservoir drawdown zone between elevations 741m and 754m, using a combination of aerial photographic interpretation at 1:5,000 scale and field measurements of biomonitoring transects.

4.2.2 Status

This monitoring program was initiated in June 2007 and will be carried out bi-annually over 10 years, starting in 2008. The next program report is expected in December 2008.

4.2.3 Interpretation of Data

In 2007, 18 vegetation communities were delineated in the drawdown zone of Kinbasket Reservoir between 742 m and 754 m ASL. The 18 vegetation communities covered 2,764 ha in 13 geographic areas. One of these communities, the Buckbean - Slender Sedge community, has been previously described in British Columbia; the remainder have not and are likely unique to the drawdown zone of this reservoir. Several vegetation communities were unique to specific geographic areas sampled in 2007.

Related to the vegetation study was a preliminary assessment of the wildlife habitat suitability of the drawdown zone. A total of 140 species of wildlife in six groups (amphibians, reptiles, mammal, birds, butterflies, and dragonflies) were documented in the drawdown zone of Kinbasket Reservoir.

The data collected in 2007 provide a baseline for future monitoring of the vegetation communities in the drawdown zone of Kinbasket Reservoir. Because these data represent only Year 1 of a 10-year study, no conclusions can be provided at this time with respect to how the operational regime of Kinbasket Reservoir affects the spatial extent and species richness of vegetation communities in the drawdown zone.

4.3 CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir

4.3.1 Overview

The WUP CC supported reservoir-wide revegetation in the Kinbasket Reservoir to increase vegetation growth in the drawdown zones in lieu of maintaining lower reservoir levels. One of the primary objectives of the revegetation program is to provide benefits to wildlife through increased habitat diversity. In association with the revegetation program, the WUP CC recommended effectiveness monitoring to ensure that the revegetation program provides the intended environmental benefits. The rationale for the monitoring program is to assess the effectiveness of revegetation in Kinbasket Reservoir at enhancing wildlife habitat by monitoring wildlife utilization patterns of revegetated habitats in the drawdown zone.

The CC recommended that baseline data be collected in Years 1 and 2, followed by monitoring every other year. In Years 5 and 11, results from this study and related studies will be evaluated to assess how effectively the revegetation program is enhancing wildlife habitat.

The objectives of this study are to:

- 1) Develop an effectiveness monitoring program to assess the success of revegetation program in Kinbasket Reservoir at increasing wildlife utilization of the drawdown zone and assess the potential effects of revegetation on wildlife populations.
- 2) Monitor wildlife indicator taxa to assess the effects of revegetating the drawdown zone on those taxa and their utilization of drawdown habitat in Kinbasket Reservoir.

The proposed monitoring indicators¹ include:

- a. Small mammals
- b. Ungulates

¹d and e will be monitored separately under CLBMON-36: Kinbasket and Arrow Lakes Reservoirs Nest Mortality of Migratory Birds and CLBMON-37: Kinbasket and Arrow Lakes Amphibian and Reptile Life History and Habitat Use Assessment. Both studies are to be initiated in 2008.

- c. Terrestrial Arthropods
 - d. Avian nest mortality
 - e. Amphibian and reptiles
- 3) Assess how effective the revegetation efforts are at improving habitat for wildlife in the drawdown zone between 741 m and 754 m elevation.
 - 4) Report and provide recommendations on the effectiveness of the revegetation program at improving habitat for wildlife in the drawdown zone in Years 5 and 11 (2012 and 2018, respectively).

4.3.2 Status

This monitoring program has not yet been initiated. Terms of Reference were submitted to the CWR on 25 January 2008, and Leave to Commence is pending. Monitoring will commence in May 2008 and will be carried out over 11 years. The first program report is expected in April 2009.

4.3.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.4 CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the Arrow Lakes Reservoir

4.4.1 Overview

The WUP CC supported reservoir-wide revegetation and wildlife physical works to enhance wildlife habitat in drawdown zone of the Arrow Lakes Reservoir. In association with these programs, the WUP CC recommended effectiveness monitoring to ensure that the physical works provide the intended environmental benefits. The rationale for the monitoring program is to assess the effectiveness of the revegetation and wildlife physical works in Arrow Lakes Reservoir by monitoring wildlife utilization patterns of revegetated and enhanced habitats in the drawdown zone.

The CC recommended that baseline data be collected in Years 1 and 2, followed by monitoring every other year. In Years 5 and 11, results from this study and related studies will be evaluated to assess the effectiveness of the revegetation program.

The objectives of this study are to:

- 1) Develop an effectiveness-monitoring program to assess the success of the revegetation and wildlife physical works programs in Arrow Lakes Reservoir at increasing wildlife utilization of the drawdown zone and assess the potential effects of revegetation on wildlife populations.
- 2) Monitor wildlife indicator² taxa to assess the effects of the revegetation and the wildlife physical works on those taxa and their utilization of drawdown zone

² The suite of monitoring indicators has not been determined as of yet, as the Terms of Reference has not been prepared. Submission of this TOR to the CWR has been deferred until 2009.

habitat in the Arrow Lakes Reservoir.

- 3) Report and provide recommendations on the effectiveness of the revegetation and wildlife physical works at improving habitat for wildlife in the drawdown zone in Years 5 and 11.

4.4.2 Status

Submission of the TOR for this monitoring program was deferred until 26 January 2009 as it is not possible to define the level of effort required or target areas for monitoring in the absence of detailed site-specific prescriptions for the revegetation program and design for the wildlife habitat structures. As a result, the monitoring program will not be initiated until spring 2009. The first program report is expected in March 2010.

4.4.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.5 CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis

4.5.1 Overview

The final decision of the Columbia River Project WUP CC to support a revegetation program for the mid Columbia River (Revelstoke Reach) and the Arrow Lakes Reservoir was based on the assumption that the soft operational constraints operating regime would be effective in maintaining current levels of vegetation, and that revegetation activities would be a more cost-effective means of restoring and expanding vegetation cover for ecological and social benefits than imposing hard constraints on operation of the reservoir. In accepting soft constraints for the Arrow Lakes Reservoir, the WUP CC recognized that the uncertainty associated with the response of vegetation communities to flexible operations on a yearly basis needed to be addressed, and consequently recommended a monitoring approach comprised of a series of interlinked studies at different spatial scales to investigate the effects of the operating regime on riparian and wetland vegetation at the landscape, site and organism level.. This monitoring program will focus on monitoring existing vegetation and revegetated areas at the *site (local)* scale.

The objectives of this monitoring program are to:

- 1) Determine the species composition (i.e., distribution, distribution and vigour) of existing vegetation communities, b) to identify species that have been successfully surviving long-term inundation;
- 2) Evaluate the abundance and biomass of existing vegetation communities in relation to elevation in the drawdown zone;
- 3) Monitor the response of existing vegetation communities at the local (site) level to the continued implementation of the soft constraints operating regime and other environmental variables;

- 4) Assess the long-term effectiveness of the revegetation program at restoring and expanding the quality (as measured by diversity, distribution and vigour) and quantity (as measured by cover, abundance and biomass) of vegetation in the drawdown zone for ecological and social benefits; and,
- 5) Assess the costs and benefits of the recommended revegetation prescriptions applied under the Arrow Lakes Reservoir Revegetation Program physical works) by monitoring the response of revegetated communities to different treatments in the drawdown zones of the reservoir.

These objectives will be addressed by assessing the specified response variables at sample sites, stratified by primary topographic and biophysical criteria, under the various treatment options relative to control sites (areas of naturally established vegetation and barren reference sites). Vegetation responses will be monitored over a range of geographic areas within the drawdown zone of Arrow Lakes Reservoir, based on locations selected for treatment under the Arrow Lakes Reservoir Revegetation Program.

This monitoring program involves:

- 1) Determining the species composition (i.e., distribution, distribution and vigour) of existing vegetation communities to identify species that have been successfully surviving long-term inundation;
- 2) Evaluating the cover, abundance and biomass of existing vegetation communities in relation to elevation in the drawdown zone;
- 3) Monitoring the response of existing vegetation communities at the local (site) level to the continued implementation of the soft constraints operating regime for the Arrow Lakes Reservoir and other environmental variables;
- 4) Assessing the long-term effectiveness of the revegetation program at expanding the quality (as measured by diversity, distribution and vigour) and quantity (as measured by cover, abundance and biomass) of vegetation in the drawdown zone for ecological and social benefits; and,
- 5) Assessing the costs and benefits of the revegetation prescriptions applied under the Arrow Lakes Reservoir Revegetation Program physical works by monitoring the response of revegetated communities to different treatments in the drawdown zone of the reservoir.

4.5.2 Status

This monitoring program has not yet been initiated. Terms of Reference were submitted to the CWR on 25 January 2008, and Leave to Commence is pending. Monitoring will commence in May 2008 and will be carried out over 10 years. The first program report is expected in December 2008.

4.5.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

4.6 CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area

4.6.1 Overview

The WUP CC recommended that studies be undertaken to gain a better understanding of the life history and habitat requirements of mosquito species occupying habitats in the Revelstoke area to determine any potential effects of dam discharge and reservoir operations on mosquito levels in the area. The WUP CC recommended monitoring studies to address uncertainties related to:

- The species of mosquito that inhabit the Revelstoke area, and which species are likely to be a nuisance to humans/livestock;
- Habitat and vegetation types occupied by mosquitoes in relation to the zone of influence of BC Hydro operations;
- Areas that constitute prime mosquito breeding grounds;
- Critical discharges and durations of flooding at which mosquito hatching occurs;
- Environmental and biotic factors affecting egg hatching and larval survival (e.g., seasonal temperatures, precipitation, predators);
- Effects of vegetation management and wildlife physical works in the drawdown zone on mosquito production (species and abundance); and
- The risk of potential mosquito vectors for West Nile virus (WNV) in the Revelstoke area.

Given the interrelation of the mosquito studies recommended by the WUP CC, four studies were combined into a single study to ensure integration of study results. This study will be conducted in 2009. The key objective of the study is to determine whether there are water management strategies and operating alternatives that could be implemented to minimize potential impacts on mosquito production in the Revelstoke area.

Study indicators include:

- a. Mosquito larvae and pupae presence, abundance, and distribution
- b. The presence, abundance, and distribution of adult mosquitoes including those species most likely to be vectors of WNV
- c. Water levels and temperature

This study will entail mosquito larval and pupal dip-net sampling, trapping of adult mosquitoes using light, gravid, and emergence traps, and monitoring water levels and temperatures in the drawdown zone. The study will also compile historical climate data, document evidence of mosquito nuisance, and map potential breeding grounds for different mosquito species.

4.6.2 Status

This inventory program has not yet been initiated. Terms of Reference were submitted to the CWR on 25 January 2008, and Leave to Commence is pending. Sampling will commence in June 2009 and will be carried out over one year. The program report is expected in December 2009.

4.6.3 Interpretation of Data

At this time, there are no data to interpret for this inventory program.

4.7 CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation Resources

4.7.1 Overview

During the Columbia River project WUP process, the WUP CC made several assumptions regarding vegetation tolerances to inundation and responses to changes in the hydrologic pattern, based on information gained from studies in the Arrow Lakes Reservoir. Given differences in the elevation, climate and operating regime of the two reservoirs, the WUP CC recognized the inherent uncertainties of any assumptions related to the response of vegetation to reservoir operating conditions, and acknowledged the importance of long-term data collection for assessing the effects of the operating regime on vegetation at different spatial scales.

The Arrow Lakes Reservoir Inventory of Vegetation Resources monitoring program will address key uncertainties related to the relative contribution and importance of the soft constraints reservoir operating regime (i.e., timing, duration and depth of inundation, and multi-year stresses) on the maintenance of existing vegetation communities delineated at the landscape scale.

The objectives of this monitoring program are to:

- 1) Identify and spatially delineate existing riparian and wetland vegetation communities within the drawdown zone;
- 2) Measure the spatial extent, structure and composition (i.e. distribution and diversity) of the communities in the drawdown zone at repeated time intervals over a 10 year period;
- 3) Assess whether there are changes in the spatial extent, structure and composition of the communities in the drawdown zone over the monitoring period;
- 4) Assess whether observed changes in the spatial extent, structure and composition are attributable to the soft constraints operating regime of the reservoir; and,
- 5) Provide information on the effectiveness of the soft constraints operating regime at maintaining the existing spatial extent, structure and composition of the communities in the drawdown zone.

These objectives will be addressed through a landscape level analysis of vegetation community changes over time in response to the soft constraints operating regime.

This monitoring program involves evaluating changes in the existing vegetation communities in the reservoir drawdown zone between elevations 434m and 440m, using a combination of aerial photographic interpretation at 1:5,000 scale and field measurements in biomonitoring plots.

4.7.2 Status

This monitoring program was initiated in June 2007 and will be carried out bi-annually over 10 years, starting in 2008. The next program report is expected in December 2008.

4.7.3 Interpretation of Data

In 2007, 16 vegetation communities were delineated in the drawdown zone of the Arrow Lakes Reservoir between 433m and 440 m ASL. The 16 vegetation communities covered 2,139 ha in 11 geographic areas.

Results of the mapping analysis show that the vegetation of the Arrow Lakes Reservoir was generally uniform. The vegetation was dominated by a few species, and Reed Canary Grass was the most frequent. The vegetation was sparser, but taller and richer in the high elevation plots. Vegetation covers and heights increased with slope, except on very steep slopes. Broad differences in vegetation cover, median vegetation height and frequencies of map units of different community types were observed between the Arrow Lakes portion of the reservoir and the Revelstoke Reach portion.

It is expected that the inundation regime, as well as terrain texture, terrain stability, coarse fragment content, water availability and effects of scouring will help to explain variation in vegetation spatial extent (i.e. cover), species composition and height.

The inventory of vegetation resources of the Arrow Lakes Reservoir also resulted in 1:5,000 scale mapping and landscape level vegetation classification and habitat suitability mapping for eight wildlife taxa. Habitat suitability for wildlife was found to be greater in the Revelstoke Reach, Beaton Arm and middle Narrows portions of the Arrow Lakes than in other parts of the reservoir. Use by Canada Goose, elk, coyote, white-tailed deer and black bear was observed to be very heavy at times throughout the reservoir.

4.8 CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation

4.8.1 Overview

From 1991 to 1993, wetland trials were conducted in the Revelstoke Reach portion of Arrow Lakes Reservoir to examine the feasibility of establishing a perennial cover of native wetland species for dust control in the drawdown zone. Long-term monitoring of the survival of these species and monitoring of permanent plots yielded valuable information regarding individual species tolerances to water level fluctuations as a result of the reservoir operating regime. However, these plots did not span the full

range of elevations now occupied by natural vegetation within the drawdown zone (approximately 440m to 430m), and there was no subsequent testing of the absolute limits of plant endurance or which aspects of the reservoir operating regime (i.e., inundation timing, frequency, depth or duration) are the most significant for plant survival. This lack of specific information hindered the WUP CC's ability to assess the performance of operating alternatives for Arrow Lakes Reservoir on existing vegetation communities. Numerous assumptions were built into the vegetation performance measures, which the WUP Consultative Committee (WUP CC) acknowledged needed to be tested to improve future decision making regarding reservoir management.

This monitoring program will be implemented at the scale of the individual organism (plant spatial scale) to document the responses of individual plants to the stresses imposed by the soft constraints operating regime. The program will address existing uncertainties regarding the relative contribution and importance of timing, frequency, depth and duration of inundation on plant survival at different sizes and ages, and the effect of multi-year stresses on trends in plant viability.

The objectives of this monitoring program are to:

- 1) evaluate the responses of plants of different species and ages to timing, frequency, duration and depth of inundation; and,
- 2) provide organism-level information required to link the effects of reservoir operations to larger-scale trends in vegetation composition, structure and spatial extent.

These objectives will be addressed through an experimental approach, involving both reciprocal field transplants and greenhouse culture, to determine the relative importance of timing, frequency, duration and depth of inundation to survival of plants of different species and ages (seedlings and mature plants).

This monitoring program involves a 5-year field program to investigate the effects of variable water levels encountered during these years under the soft constraints operating regime. In addition, greenhouse experiments will be implemented for four successive years to allow for controlled experimental testing of a range of inundation conditions imposed by the operating regime and/or to test alternate species

4.8.2 Status

This monitoring program has not yet been initiated. Terms of Reference were submitted to the CWR on 25 January 2008, and Leave to Commence is pending. The program will commence in April 2010 and will be carried out over five years. The first program report is expected in December 2010.

4.8.3 Interpretation of Data

At this time, there are no data to interpret for this monitoring program.

5 Summary of Columbia River WUP Physical Works - Kinbasket & Arrow Lakes Revegetation Management Plan

This section summarizes the status of the physical works being implemented under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan of the Columbia River Water Use Plan, as per the Order under the *Water Act*, dated January 26, 2007.

5.1 CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Work

5.1.1 Overview

The Columbia River Project WUP CC recognized the value of vegetation for improving aesthetic quality, controlling dust, protecting cultural heritage sites from erosion and human access, and enhancing littoral productivity and wildlife habitat. Therefore, the WUP CC supported a reservoir-wide planting and enhancement program in lieu of operational changes during the growing season, to maximize vegetation growth in the drawdown zone and to facilitate the development of long-term self-sustaining riparian vegetation. This program will target the upper elevations of the Kinbasket Reservoir drawdown zone between elevations 747 m and 754 m, and investigations will be undertaken to examine the feasibility of extending vegetation into lower portions of the drawdown zone to a lower limit of 741 m.

The objectives of this physical work are to:

- 1) maximize vegetation growth in the drawdown zone;
- 2) provide benefits to littoral productivity and wildlife habitat through increased plant species diversity;
- 3) improve shoreline stability through targeted planting, where possible;
- 4) increase the species diversity of native plants, particularly those of interest to First Nations; and,
- 5) provide increased protection for known archaeological sites, where possible.

These objectives will be achieved through application of a variety of prescriptions in suitable sites that specifically target the above values.

5.1.2 Status

This physical work was initiated in June 2007 and will be carried out over five years. Field work conducted in Year 1 of this project has confirmed that approximately 1525 ha of the drawdown zone of Kinbasket Reservoir above elevation 747 m are suitable for vegetation enhancement. A total of 26 sites were surveyed between elevations 747 m and 754 m in 2007.

Blanket prescriptions utilizing a limited number of target species have been prepared based on a 2007 assessment of vegetation currently found in the drawdown zone, as well as site and substrate conditions. These prescriptions will be implemented on an experimental basis in 2008, as described in the TOR (CLBWORKS-1 Phase 2).

These TOR have been submitted to the CWR and Leave to Commence is pending. The next physical works report is expected in December 2008.

5.2 CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Work

5.2.1 Overview

The Columbia River Project WUP CC recognized the value of vegetation for improving aesthetic quality, controlling dust, protecting cultural heritage sites from erosion and human access, and enhancing littoral productivity and wildlife habitat. Based on the success of vegetation treatments for dust control in Revelstoke Reach (the mid Columbia River), the WUP CC agreed that establishing permanent vegetation cover in the drawdown zone of Arrow Lakes Reservoir and Revelstoke Reach was the best option for achieving the multiple objectives set by the committee. This program will target the upper elevations of the Arrow Lakes Reservoir drawdown zone between elevations 434m and 440m.

The objectives of this physical work are to:

- 1) maximize vegetation growth in the drawdown zone;
- 2) provide benefits to littoral productivity and wildlife habitat through increased plant species diversity;
- 3) improve shoreline stability through targeted planting, where possible;
- 4) increase the species diversity of native plants, particularly those of interest to First Nations; and,
- 5) provide increased protection for known archaeological sites, where possible.

These objectives will be achieved through application of a variety of prescriptions in suitable sites that specifically target the above values.

5.2.2 Status

The first phase of the Arrow Lakes Reservoir revegetation program was initiated in June 2007. Implementation of this physical work will be carried out over five cumulative years, as described in the TOR (CLBWORKS-2 Phase 2). This TOR was submitted to the CWR on 26 February 2008 and Leave to Commence is pending.

The final two years of the revegetation program (Phase 3) will be implemented in conjunction with CLBWORKS-30 Arrow Lakes Reservoir Wildlife Physical Works to ensure that revegetation efforts are targeting those areas where wildlife habitat benefits can be maximized.

Field work carried out in 2007 identified 28 sites (nine in Revelstoke Reach and 19 sites in the Arrow Lakes) as suitable for revegetation, for a total of 393.4 ha (116.0 ha in Revelstoke Reach and 277.4 ha in the Arrow Lakes). The field assessment revealed that substantially less area is available for revegetation than identified during the preliminary work conducted in 2003 as part of the Columbia River WUP. The reasons for the reduced need for planting is partly because of the Consultative

Committee's decision to establish 434m as the lower boundary for the revegetation program physical works, and also the recent pattern of low water levels in the latter part of the growing season, which has been beneficial for vegetation growth and expansion in the drawdown zone. Because of favourable growing conditions, many of the sites above 434m, which were unvegetated at the time of the previous vegetation mapping, are now partially to fully vegetated. The areas not currently vegetated appear to be "problem sites", where wind or water erosion and substrates present unique challenges to vegetation establishment. Revegetation of these sites will occur over two years commencing in 2009. Collection of seed stock for lenticular sedge and other suitable species will take place in the summer of 2008 (water levels permitting) to ensure that local seed is available for raising nursery stock in 2009.

The next physical works report for the revegetation program is expected in December 2008.

6 Kinbasket & Arrow Reservoir Revegetation Management Plan - Monitoring Programs and Physical Works Costs

The following table summarizes the approved costs of the monitoring programs and physical works under the Kinbasket & Arrow Lakes Reservoirs Revegetation Management Plan of the Columbia River WUP, as well as the Actual Costs to 31 January 2008.

Table 6-1: Columbia River Monitoring Programs and Physical Works Costs

Description	Costs Approved by Comptroller of Water Rights	Actual Costs to 31 Jan 2008
Monitoring Programs		
CLBMON-9 Kinbasket Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis	Direct Management	\$11,429
	Implementation	
CLBMON-10 Kinbasket Reservoir Inventory of Vegetation Resources	Direct Management	\$97,315
	Implementation	\$1,083,142
CLBMON-11A Wildlife Effectiveness Monitoring of Revegetation in Kinbasket Reservoir	Direct Management	\$185,103
	Implementation	\$1,780,463
CLBMON-11B Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the Arrow Lakes Reservoir	Direct Management	
	Implementation	
CLBMON-12 Arrow Lakes Reservoir Monitoring of Revegetation Efforts and Vegetation Composition Analysis	Direct Management	\$9,293
	Implementation	
CLBMON-13 Inventory of Mosquito Populations in the Revelstoke Area	Direct Management	\$26,962
	Implementation	\$84,688
CLBMON-33 Arrow Lakes Reservoir Inventory of Vegetation	Direct Management	\$89,191

Description		Costs Approved by Comptroller of Water Rights	Actual Costs to 31 Jan 2008
Monitoring Programs			
Resources	Implementation	\$1,212,168	\$274,104
CLBMON-35 Arrow Lakes Reservoir Plant Response to Inundation	Direct Management		\$7,067
	Implementation		
Physical Works			
CLBWORKS-1 Kinbasket Reservoir Revegetation Program Physical Works-Phases 1&2	Direct Management	\$117,026	\$35,064
	Implementation	\$2,449,714	\$109,529
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works –Phase 1	Direct Management	\$37,732	\$36,396
	Implementation	\$104,718	\$76,750
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works –Phase 2	Direct Management		
	Implementation		
CLBWORKS-2 Arrow Lakes Reservoir Revegetation Program Physical Works –Phase 3	Direct Management		
	Implementation		